Corn Insects

Integrated Pest Management

Integrated Pest Management (IPM) is a strategy that blends science, art and experience. Its goal is to prevent pest populations from building to a point where they cause unacceptable economic losses, so that the producer's yield goals can be achieved in the most economically and environmentally sound manner possible. There are many tools for achieving this goal, and pesticides have a role. However, pesticides should be used only when pest populations reach the economic threshold level and other options have failed.

A pest management strategy that includes more than one tactic is generally more stable and cost-effective than one that relies on a single tactic.

There are four components to an IPM plan—prediction, prevention, detection (scouting) and remedial action. Carrying out the first three properly often eliminates the need for remedial action.

Prediction involves anticipating problems before they occur. Experienced producers often can predict pest problems based on weather, the cropping system used (such as no-till or conventional tillage), and past pest problems. There are also computer models for predicting pest outbreaks. Irrigation requirements can be predicted to some extent by using ET (evapotranspiration) data for the current year and past years.

Prevention is often the least expensive and most effective way to save money on pest management. Producers who rotate crops, alter planting dates to avoid peak pest outbreaks, practice proper sanitation to destroy insects and sources of disease innoculum, plant resistant varieties and/or transgenic varieties, preserve beneficial insects, fertilize properly, and prevent undue water stress at critical corn growth stages usually have the lowest pest management costs.

Detection of pests involves scouting fields regularly—at least once a week. Scouts should check for pest insects, beneficial insects, diseases, weeds, plant nutrition problems, and water stress. Scouting after a pesticide application (insecticide, miticide, fungicide, herbicide) is important to determine whether the pesticide is providing good control.

A number of Extension agents and specialists publish weekly pest management newsletters to help producers keep current on what is happening in area crops. Many of these newsletters have insect trap capture and actual field scouting information that can serve as an early warning of pending problems. These newsletters can be found on the county Extension Web site (*http://county-tx.tamu.edu/*). Contact your county Extension office to subscribe. Private industry also provides newsletters and pest updates.

Remedial action (often thought of as "control") is an intervention to lower the number of pests in a field. All remedial actions cost something to implement, so it follows that they should not be used until the cost of the pest damage equals or exceeds the cost of the intervention. This concept is at the core of "threshold" theory. The "economic injury level" is the point at which the dollar value of the pest damage equals the cost of control. Because it may take several days to implement a control measure and see its effect, it may not be a good idea to wait until the economic injury level is reached before taking remedial action. Rather, control decisions should be made before the economic injury level is reached. The "economic threshold" is the pest density that justifies control, factoring in the amount of damage pests will continue to do in the time it takes to implement that control. In terms of pest numbers, the economic threshold is a little lower than the economic injury level. The economic threshold signals the need for pest control at precisely the right moment to prevent the economic injury level from being exceeded.

Economic Thresholds

Economic thresholds are guidelines based on research. They are not perfect, but they are usually fairly accurate. A perfect economic threshold would change as the price of control measures changed and/or the per bushel value of corn changed. In reality, many published thresholds do not change as corn prices and control costs fluctuate. These types of thresholds are called "static" because they do not change to reflect actual values and costs. Are they bad thresholds? No, they are just not as good as they could be. Growers and consultants often adjust static thresholds to reflect current market prices for corn. There is nothing wrong with this. Most static thresholds assume that corn is valued at $2.50 per bushel or more. If corn is worth less, the economic threshold is higher. In a simplified example, if an insecticide application to control a grain-feeding insect costs $10.00 per acre, the economic injury level would be $10.00, or a yield loss of 4 bushels of $2.50 corn per acre. If corn were valued at $2.00 per bushel, the economic injury level would still be $10.00, but this would be 5 bushels lost. It takes more insects to eat 5 bushels of grain than to eat 4 bushels of grain, so the economic threshold is adjusted upward as the price of the corn decreases.

While thresholds are simple to determine if a pest feeds directly on the grain, they are harder to determine if a pest damages other plant parts and the damage has an indirect effect on yield.

"Dynamic economic thresholds" are more accurate than static thresholds in estimating economic injury levels because they change to account for different values of the crop, cost of control, and sometimes the growth stage of the crop or life stage of the pest. The Texas spider mite threshold is one example; the economic threshold changes with the value of corn and the cost of control. Dynamic thresholds take a little more effort to apply, but usually give better economic results than do static thresholds.

In the end, economic thresholds are guidelines. They are reasonably good indicators of when control measures should be implemented. There are few hard and fast rules in Integrated Pest Management, and that is why we acknowledge that it is a blend of science, art and experience. This manual can be a valuable resource, but please use the companion Web site at *http://lubbock.tamu.edu/cornIPM* for the most current updates. Also remember that county Extension agents, agricultural consultants, agribusinesses, and other Web sites can provide excellent information.

Scouting

To make sound pest management decisions you must have accurate and timely information about what is happening in the crop. Corn should be scouted at least weekly, and more often when pest numbers are building. It should also be scouted as soon as possible (based on reentry interval) after an insecticide application, because it can't be assumed that the application was effective. There are no hard and fast scouting rules that must be followed, but there are guidelines based on experience. Crop consultants become very familiar with the fields in their areas and have a solid idea of what is happening in those fields. Their constant familiarity with the emerging pest profile lets them concentrate on developing problems rather than spending time on pests they know are not important at the current time.

For people not so devoted to keeping tabs on the pest profile, the task may be a bit more difficult. An Extension newsletter about pest management in your county will help you fill in the picture every week. Extension pest management agents can train you to scout your fields, identify insects, and make control decisions. They are there to help producers, so don't hesitate to call them.

It does take time to accurately estimate the pest situation in a field, and time is a resource that must be managed wisely. The amount of time devoted to scouting depends in part upon the type of information you are trying to collect and what you intend to do with that information. Scouting to determine pest numbers in relation to economic thresholds is rather straightforward. That is why this manual was written—as a practical aid to making pest control decisions based on current and projected pest populations. However, if you are attempting to determine the dispersion of a pest within a field, track changes over time, or determine the ratio of beneficial insects to pests, be prepared to spend more time in the scouting process. Sampling techniques for such needs can be quite involved and are not addressed in this manual.

The job of a scout is to determine the "average" infestation in the field and provide information on the amount of variability associated with that average. This is where scouting and statistical theory collide. Statistically valid sampling procedures that allow very accurate estimates of the average infestation level of a pest generally require that many locations and plants be checked. Scouts often cannot devote enough time per field to satisfy the strict requirements of statistically valid sampling. In the end, a scout falls short of perfect counting, but must still generate an acceptably accurate picture of what is happening in the field. **The scout must always protect against unjustified economic loss, and if a field is approaching an economic threshold, he or she must devote the time required to estimate pest numbers fairly accurately. Scouting takes more time when a field infestation is nearing the economic threshold level.** More time is also required when counts vary widely in different parts of the field. However, if the field is well below or well above the economic threshold, the scout can make a "no treatment needed" or "remedial action needed" decision rather quickly.

Variations in pest counts may result from plant differences caused by soil type or fertility, drainage, organic matter, weediness, plant variety, or other factors. Many insects lay eggs only in areas that meet certain criteria, avoiding areas that don't match those criteria. For example, many cutworm species lay eggs on weeds before corn is planted. A weedy area of the field is more likely to have a cutworm infestation than a weed-free part of the field. Another example is the European corn borer's preference for laying first-generation eggs in taller corn. A good scout will choose some locations with taller corn and some with shorter corn when determining the average infestation.

Other differences in pest counts between locations may be a function of the pests themselves. Some pests tend to remain "clumped" in areas of the field rather than being evenly distributed. This is particularly true at low levels of infestation. A scout may walk into a "hot spot" in one place, but would have recorded very low pest numbers just a few yards away. Other pests may vary according to a "gradient," or become more or less numerous as one moves through the field. For example, spider mite infestations often begin on the side of the field from which the prevailing wind blows and then spread downwind through the field. A good scout will spend more time in the areas where problems are likely to occur first and then track the pests as they move into the interior of the field. Nonrandom pest distribution makes scouting more difficult and generally requires that more locations be checked per field.

The "edge" is the outside 75 feet on each side of a field. Pest counts in the edge are often higher and more variable than in the rest of the field. Therefore, sampling in an edge is discouraged except where insects are moving in from an edge and a spot treatment may be needed. A small field has lots of "edge" or border in relation to the total number of acres in the field. A square 40-acre field is 1,320 feet long on each side. A 75-foot edge around all four sides equals 8.6 acres, or 21 percent of the area in the field! In contrast, a square 120-acre field is 2,286 feet long on each side. A 75-foot edge around all four sides equals 11.6 acres, or only 9.7 percent of the entire field. Thus, the smaller the field, the larger the percentage that is occupied by the "edge." It would seem, then, that smaller fields would have more variability in insect counts than large fields. But large fields often have lots of variability in pest numbers also.

Some corn scouting guides recommend that every 40-acre block of corn be scouted in five locations, which implies that a 120-acre field should be scouted at 15 locations and a 320-acre field at 40 locations. In reality, the number of locations to scout depends on how much variation there is in the field, whether the field is large or small, whether the pests are evenly distributed in the field, and what is growing outside that field to influence pests moving into the field.

A scout who walks a square grid pattern in a 40-acre field and takes samples at four locations separated by 400 yards on each side covers about 83 percent of the field. The same scouting route would cover only 28 percent of a 120-acre field and 10 percent of a 320-acre field. The field estimate "average" reported by a scout becomes less and less reliable as less of the field is examined. It is imperative that the "average" be accurate. Larger fields usually must be sampled at more locations than smaller fields, although there is a minimum number of samples needed no matter how small the field.

Scouting is meant to determine the average pest density in a field. Because there is less edge effect in larger fields, scouts often take fewer samples per unit of area (but the total number of locations sampled is higher). A 40-acre field should be scouted at a minimum of five locations. Five locations might be enough for a 120-acre field if the pests are evenly distributed, but there is a significant risk of missing something important. It is best to scout in more than five locations in larger fields. Scouting too few locations will increase the risk of error. Scouting too many locations will not appreciably improve the accuracy or precision of the pest count, and it will take more time.

Do not ignore low spots, weedy areas, or any other unusual part of the field. By the same token, be certain that the pest counts from these areas are not disproportionately represented in the "average" count for the field.

The sampling locations should be widely separated. Taken as a whole, they should represent the field. Don't sample the same locations of a field week after week unless you have a good reason to do so, such as determining if pest numbers have changed in a specific location. Mix sampling locations up and move around. It could be that by returning to the same general place each week you are missing something important in the areas that are ignored.

Never sample fewer than ten plants per location. These plants can be consecutive in one row, but the first plant should be chosen at random. There is a natural tendency to choose as the first plant one that is strange. We notice the exception to the normal and give it special attention. A good field scout will make sure the first plant is chosen at random by either taking a certain number of predetermined steps and choosing the plant that is closest to his or her foot, or throwing an object a few feet ahead and choosing the plant nearest to the object.

Look for anything that is unusual. Take samples of diseases and insects if you are not certain what they are. Note soil compaction, plant water status, nutrient deficiencies, weed species, plant growth stage, and the general number of beneficial insects and spiders.

Don't cut corners. A scout is the eyes of the grower and is responsible for accurately assessing the situation each week. A scout is never criticized for providing too much information to a grower. Be sure of what you say. Spend the time it takes to do a thorough job; your diligence will be appreciated.

Finally, all individuals make mistakes. If you discover that you missed something important, go to the grower or your supervisor immediately and explain the situation. There may still be time to correct the problem. Identify why you made the mistake and then correct your practices so as to avoid the same error in the future. Scouting is hard work, but when done properly it can be very rewarding. When done poorly, it can be very costly.

Submitting Samples for Identification

County Extension agents and Extension entomologists can identify insect samples. This service is generally provided for free. No appointment is necessary, but it is best to call ahead to make sure your county agent will be in the office.

Samples also can be submitted through the mail if prepared properly. With the exception of moths, the best way to prepare insect samples for identification is to put them in 70% alcohol—the type sold at grocery and drug stores. Alcohol will kill the insects and preserve them for a time. To prepare larvae for shipping, first place them in boiling water for 1 minute and then transfer them to alcohol. The heat will stop the enzymes in the body and prevent the specimens from turning black in a day or so. Bring the water to a boil, remove it from the heat source, and then add the larvae. Do not add the larvae while the water is being heated.

Be sure the container of alcohol does not leak. Mason jars, baby food jars, and other containers with gaskets work best. Do not use pill bottles and other containers without gaskets. Always include a note with information about the affected crop, the growth stage of the crop, the damage being done, how severe and widespread the damage seems to be, and your address and telephone number. Write your note in pencil. Most pen ink will dissolve in alcohol, and poorly sealed jars of alcohol will obliterate your note.

Insect specimens can be shipped dry in plastic Ziploc®-type bags, along with a sample of a damaged plant. It is best to put some paper toweling in the bag to absorb moisture. However, if the mail is delayed or is not opened for some time, the samples will usually be rotten and beyond recognition. Do not mail dry samples in envelopes. The canceling machinery at the post office will squash the insect. Always mail samples in a box. When submitting a dry specimen (one not preserved in alcohol), mail it for delivery on Tuesday through Friday. Avoid Monday delivery because the sample will sit in the post office over the weekend.

Digital images are replacing actual insect specimens for identification purposes. The advantage of a digital image is that it can be “delivered” instantly. Get the best image possible, and get as close to the specimen as you can. Digital images work well for common and abundant pests, but they are very poor substitutes for a real specimen when the insect is uncommon or unusual. When submitting a digital image via e-mail, always include all relevant information and be sure to send a telephone number. If the specialist is unable to identify the pest from its image, he or she will either call you back or notify you by e-mail.

Practical Entomology

Entomology can be baffling for most people, in part because entomologists use Latin words and complicated terms to describe insect species, body parts and insect development. This section explains a few important principles of entomology in words that make sense.

Insect Development

With the exception of aphids that bear live young, all insect pests found in corn start from eggs laid by the females in the soil or on the plant. After hatching, immature insects go through several growth stages, shedding their skin at the end of each stage. They need to do this because the “skin” we see is actually a skeleton on the outside of the insect’s body. The immature insect can’t continue to grow while encased in a skeleton that is too small. Each immature stage is called an “instar” and is given a number. The first stage is called a “first instar,” the next, larger stage is called a “second instar,” and so forth until the last immature stage is reached. The number of immature stages varies with the species and sometimes with the environment and the quality of food available.

This process of change through the life stages is called **metamorphosis.** There are two types of metamorphosis in insects. In **simple** metamorphosis, the immature stages closely resemble the adults except that they are smaller and their wings and reproductive organs are not fully developed. In the U.S. we often use the term nymph to describe these immature insects, but European entomologists call them larvae. Grasshoppers, crickets, aphids and the true bugs are examples of insects with simple metamorphosis.

The second and more complicated type of metamorphosis is **complete.** In these species the adult looks completely different from the immature stages. Examples of insect species that undergo complete metamorphosis are moths, butterflies, beetles, flies, bees and wasps. The immature stages of insects with complete metamorphosis are called larvae. This type of metamorphosis has some advantages. For example, when larvae and adults have different mouthparts and can feed on different types of food, they don't have to compete with each other. A disadvantage of complete metamorphosis is that the insect must have a forced resting stage while it undergoes the radical changes from the larval to the adult form. This resting stage is called the pupal stage. Most insects go through the pupal stage in a secluded location such as in soil or inside a plant, which helps protect them from predators while they are immobile and helpless. The pupal stage also explains in part why insects with complete metamorphosis seem to disappear for a week or more before they emerge as adults.

Identifying Insects by Plant Damage

The type of damage you observe on a corn plant helps you identify the insect culprit because the damage indicates the type of mouthpart the pest has.

There are two types of mouthparts in insects– **teeth** or **piercing and sucking straws.** Insects with teeth (mandibles) eat by chewing holes in tissue. Insects with piercing and sucking mouthparts never chew their food, but they suck out the contents of plant cells and often inject saliva that can kill tissue. Some piercing and sucking mouthparts are elongated, tube-like structures similar to sharp soda straws. Other insects do not have such straws, but rasp or stick cell surfaces and drink the contents.

Table 6 shows the main groups of corn insect pests, the types of mouthparts they have, and the damage they cause. When you find insect damage in a field, use this table to help you identify the pest that is causing it. For example, if whorl stage corn has leaves that are ragged with tissue missing, you can assume the damage was not done by insects with piercing/sucking mouthparts (aphids, true bugs, flies or spider mites). These pests suck juices but don't have the teeth to eat tissue. You would then concentrate on caterpillars or the adults or immatures of beetles or grasshoppers. If you found oval areas of dead but intact leaf tissue, you could eliminate the insects that have chewing mouthparts, such as caterpillars, most beetles (except very small ones that can't eat through the whole leaf) and grasshoppers.

Table 6. Insect pests, type of metamorphosis, and the appearance of plant damage.

Pest group	Metamorphosis	Insect order	Stage	Mouthpart type	Damage
Caterpillars	Complete	Lepidoptera	Larva	Chewing	Tissue removed
			Adult	Siphon–sucking	None
Beetles	Complete	Coleoptera	Larva	Chewing	Tissue removed
			Adult	Chewing	Tissue removed
Grasshoppers	Simple	Orthoptera	Nymph	Chewing	Tissue removed
			Adult	Chewing	Tissue removed
Aphids	Simple	Homoptera	Nymph	Piercing–sucking	Cells disrupted, tissue intact
			Adult	Piercing–sucking	Cells disrupted, tissue intact
True Bugs	Simple	Hemiptera	Nymph	Piercing–sucking	Cells disrupted, tissue intact
			Adult	Piercing-sucking	Cells disrupted, tissue intact
Flies	Complete	Diptera	Larva	Sucking	Tissue damaged, some removed
			Adult	Sponging or piercing	None
Spider mites	Simple	Acarina (not insects)	Nymph	Sticking	Cells disrupted, tissue intact
			Adult	Sticking	Cells disrupted, tissue intact

Overwintering and Cultural Control Practices

Insects are coldblooded, which means that the temperature of their bodies tends to be near the temperature in the environment. Below a certain temperature, an insect does not move about and slows down its metabolic processes to stay alive. Some insects freeze and die at temperatures below freezing; others can withstand very low temperatures by moving to a protected location, creating an anti-freeze-like substance in their blood, or freezing with little cell damage. The difference in their ability to withstand cold temperatures explains why some insects are able to overwinter in parts of Texas and others are not. Northern pests such as the European corn borer are not challenged even by the most severe winter in Dalhart, but southern pests such as the fall armyworm cannot overwinter there. Depending upon the species, an insect may overwinter as an egg, immature or adult. Pests that can overwinter successfully begin moving into the corn crop in the spring. Pests that cannot overwinter usually arrive later through migration. Cultural control practices such as stalk destruction, deep tillage, crop rotation, and delayed planting are usually directed at pests that can overwinter. Almost all corn pests can overwinter in Texas.

Temperature and the Rate of Insect Development

The time it takes for an insect to complete a generation depends on temperature. Insects develop more rapidly as the temperature increases. This is why a pest that takes 4 weeks to complete development in May might take only 3 weeks to complete development in July. As strange as it may seem, it is unusual for insects to die from high temperatures. They do suffer heat stress, but they can get water from the plants on which they are feeding and are cooled by the plants themselves. High temperature sometimes kills insect eggs, but usually it is because the eggs are also dehydrated.

Insect Development and Insecticide Efficacy

Most insects are easier to kill when they are small, and there are two reasons why this is so. First, a toxin is lethal only at a certain weight of active ingredient per unit weight of insect. This relationship is often expressed as milligrams of insecticide per kilogram of body weight. A fifth-instar larva that is 50 times heavier than a first-instar larva will require 50 times more insecticide to kill it. Another advantage of older larvae is that they often have detoxification systems that break down insecticides to nontoxic or less toxic substances. An insect's detoxification system usually becomes more efficient as the insect gets older. Thus, an older larva has both a larger size and a better detoxification system to reduce its susceptibility to insecticides.

Integrated pest management stresses the importance of detecting pests early, although acceptable control often can be achieved even if pests are detected late. However, the behavior of the insect involved and the insect's stage of growth must be considered when deciding whether or not to apply insecticide. Some insects, such as the corn borer species, move inside the plant soon after hatching from the egg stage. Non-systemic insecticides (those not taken up in the plant) cannot reach them once they are inside the plant, so insecticide applications would be wasted. There is also a point at which there would be no economic gain from using insecticide, even though it might kill a large percentage of the insects. This point is reached when most of the insects are in their last larval stage and have done about all of the damage they are going to do. They will soon stop feeding and enter the pupal stage, so what is the point of spending money for an insecticide application that might, at best, prevent a day or two of feeding? The choice to use an insecticide is really a choice to incur a cost, and IPM is based in part on the principle that the benefits of insecticide use should outweigh the costs incurred.

Insect Naming Conventions

Most of us know insects by their common names, which often reflect the plant on which the insect feeds. For example, the corn earworm is the larva commonly found in ears of sweet corn and field corn. However, the same pest is known as the cotton bollworm and the tomato fruitworm when it attacks those plants. There is nothing wrong with using common names for pests, but in scientific circles names must be clear. Having too many names for the same insect causes confusion. Therefore, scientists have devised a rather strict system for classifying living things and for assigning a name to each species.

In this system, insects are grouped according to

- order (the most broad and inclusive group),
- family,
- genus, and
- species.

Butterflies and moths, grasshoppers, bugs, flies, and bees and wasps are in different insect orders. An order contains one to many families. A family contains one to many genera. A genus is a rather small group within a family that usually contains one to many species. A species is specific and unique.

For example, the corn earworm's scientific name is *Helicoverpa zea.* It belongs to the genus *Helicoverpa* and is the species *zea.* Other species in the genus include *Helicoverpa armigera* (the old world bollworm) and *Helicoverpa punctigera* (the native budworm). Insects in the genus *Helicoverpa* belong to the family Noctuidae and the order Lepidoptera. When an entomologist hears the family name Noctuidae, he or she immediately knows that the insect being described has a larval immature stage and the adult is a moth in the large group of insects called Lepidoptera (moths and butterflies). Scientific names provide a lot of information about an insect and are, therefore, quite helpful to people who deal with insects on a daily basis.

Another important aspect of scientific names has to do with the endings of singular and plural words, which derive from Latin. In general, plural words end in "ae" and singular words end in "a." Examples are "larvae" and "larva," "pupae" and "pupa."

Infestation Timeline

This manual describes most insect pests of corn in Texas. Many pests cause economic damage for only a short time during the growing season, while some remain a threat for much longer periods of time. Table 7 is a quick reference to the pests that may be of economic consequence at a particular stage of corn growth. These pests are discussed on the following pages in the same order as presented in Table 7.

Table 7. Seasonal progression of insect pests.

Pest	Seed/ Seedling	Whorl to pretassel	Tassel/ Silk	Grain filling
Wireworms	Yes			
White grubs	Yes			
Red imported fire ants	Yes			
Seedcorn beetles	Yes			
Seedcorn maggot	Yes			
Flea beetle	Yes			
Cutworms	Yes			
Lesser cornstalk borer	Yes	Yes		
Chinch bugs	Yes	Yes		
Southern corn rootworm	Yes	Yes		
Western corn rootworm	Yes	Yes	Yes	
Mexican corn rootworm	Yes	Yes	Yes	
Corn leaf aphid	Yes	Yes	Yes	
English grain aphid	Yes	Yes	Yes	
Fall armyworm	Yes	Yes	Yes	Yes
Armyworm	Yes	Yes	Yes	Yes
Spider mites	Yes	Yes	Yes	Yes
Southwestern corn borer		Yes	Yes	Yes
European corn borer		Yes	Yes	Yes
Mexican rice borer		Yes	Yes	Yes
Sugarcane borer		Yes	Yes	Yes
Neotropical borer		Yes	Yes	Yes
Western bean cutworm		Yes	Yes	Yes
Corn earworm		Yes	Yes	Yes
Grasshoppers		Yes	Yes	Yes